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Developing Key Performance Indicators to Improve Patient Care and Outcome at Littleton Fire Rescue

Wayne M. Zygowicz

Littleton Fire Rescue, Littleton, Colorado

CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

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Abstract

The problem was Littleton Fire Rescue (LFR) could not measure the effectiveness of its emergency medical services (EMS) and prove the fire department's patient care was positively influencing patient outcomes. Antidotal evidence indicated the fire department was providing excellent medical treatment but no key performance indicators (KPI) were developed to prove or disprove this theory. The purpose of this evaluative research was to investigate KPIs in EMS and develop measurable service delivery standards to evaluate the effectiveness of medical treatment provided by LFR. The following research questions were answered in the development of KPIs: a) What measureable performance indicators were used to evaluate the effectiveness of an EMS system? b) How do performance indicators improve patient care and outcome? and c) What methods are used by other EMS system to measure performance? Three research procedures produced results on KPIs in EMS. Procedures included a retrospective analysis of LFR's incident data, personal interviews and a national survey. Results proved that LFR was providing effective medical treatment that directly influenced patient outcomes and reduced mortality. Results also discovered treatment areas that needed improvement. Clinical and operational recommendations resulted from this study. Clinical recommendations included reducing scene time, improving treatment for cardiac patients, benchmarking reperfusion time, increasing cardiac arrest survival rates and improving treatment for patients in pain. Operational recommendations included developing non-clinical KPIs, improving individual paramedic performance, educating LFR's workforce on KPIs, improving EMS documentation and gathering patient satisfaction data through a customer survey.

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Introduction

Littleton Fire Rescue (LFR) had been providing emergency medical services (EMS) at the advanced life support level to citizens of the Littleton community since 1974. Littleton's EMS deployment strategy used experienced and well trained firefighter/paramedics using state of the art medical equipment to provide timely medical care.

The problem was LFR could not measure the effectiveness of its emergency medical services and prove their impact on patient outcome. Antidotal evidence indicated the fire department was providing high quality effective emergency medical care but no key performance indicators (KPI) had been developed to measure the systems effectiveness and prove or disprove this theory.

The purpose of this applied research project was to investigate and develop KPIs to measure, evaluate and benchmark the effectiveness of LFR's EMS system on patient outcomes. The reason for developing KPIs was to improve patient care and make certain LFR was providing the highest level of effective medical care that would reduce injuries and death.

This applied research project used evaluative research methodology to investigate KPIs in EMS and develop measurable service delivery standards to improve patient care and outcome. The following research questions were answered to assist in developing new KPIs and measurable EMS standards for LFR: a) What measurable performance indicators were used to evaluate the effectiveness of an EMS system? b) How do performance indicators improve patient care and outcome? and c) What methods are used by other EMS systems to measure performance?

Background and Significance

Founded in 1890, Littleton Fire Rescue (LFR) had provided fire suppression and emergency services to the City of Littleton, Colorado and surrounding communities for the past 120 years. The fire department protected 225,000 residents from eight fire stations within its 92 square mile fire district. LFR employed 125 cross-trained-dual-role career firefighters who were trained as emergency medical technicians. Half of the firefighters were trained to the advanced life support level of paramedic. LFR responded to 12,187 incidents in 2009 and 67% were EMS calls ("Annual Report," 2009). LFR provided advanced life support care with paramedic/ firefighters responding on each of the seven engine companies, one ladder truck and five transport ambulances.

LFR's Deputy Chief Pete Cernich developed Littleton's paramedic program in conjunction with a local trauma center in 1974. 14 Littleton firefighters attended paramedic school at Swedish Medical Center in Englewood, Colorado even before there was an official paramedic certification program or published paramedic text books. These fledgling paramedic firefighters graduated as the first official paramedics in the State of Colorado. LFR was one of the first fire based EMS systems in the country.

LFR has a long history of providing high quality effective EMS using state-of-the-art medical equipment. The fire department was known locally, regionally and nationally for outstanding patient care and excellent customer service. LFR was featured in national EMS publications as leaders and innovators in EMS. LFR was the first EMS system to use advanced cardiac monitors, automated CPR machines and induced hypothermia in cardiac arrest. LFR was only one of two EMS systems nationwide to use portable ultrasound machines in the ambulance during transport to diagnosis internal bleeding in trauma patients. The fire department gained

national notoriety in 1999 during the Columbine High School shooting. The medical care provided by LFR was credited with saving lives during the shooting incident.

The problem was LFR could not measure the effectiveness of its emergency medical services and prove their impact on patient outcomes. Since the inception of the paramedic program LFR had received numerous thank you letters, cards and visits from survivors and their families after emergency care resulted in a “save” or positive patient outcome. While antidotal evidence indicated LFR was providing excellent medical care no quantifiable performance indicators existed to prove or disprove this assumption.

This is a serious problem because without key performance indicators (KPI) to measure and benchmark performance there was no quantitative method to prove LFR’s medical care was reducing injuries and death. LFR’s operational mission is to provide the citizens with emergency response services and life safety education programs that minimized the loss of life and property from fires, medical emergencies and hazardous conditions (“Annual Report,” 2009).

The impact of the problem could increase mortality or adverse outcomes for LFR customers. KPIs will closely examine the quality of the medical services provided by LFR and performance data benchmarks will improve patient care.

As the EMS Chief for LFR and an Executive Fire Officer candidate, it is this researcher’s responsibility to guarantee that LFR’s patients are receiving the most effective and efficient emergency medical care possible at the most reasonable cost. This researcher must find ways to reduce organizational liability through EMS system quality improvement processes and paramedic over site. The development of KPIs to analyze and benchmark performance will help meet those objectives. This problem had never been studied in the 37 years that LFR had been providing advanced life support care.

This applied research project was directly related to the National Fire Academy's *Executive Leadership* course, unit 5, *managing multiple roles.* As an Executive Fire Officer it is this researcher's responsibility to measure and improve EMS system performance to reduce injuries and death. One of Mintberg's ten roles of a successful manager is to be an entrepreneur. An entrepreneur is a person who is continually "improving their organization, making the necessary changes to meet new needs and demands (ED-Student Manual, 2005, p.SM 5-3)." This problem was linked directly to the United States Fire Administration's (USFA) strategic plan and operational objective number one; reduce risk at the local level through planning and mitigation (USFA Web page, 2010). By developing KPIs to measure, analyze and benchmark EMS system effectiveness this researcher hopes to reduce community risk and adverse patient outcomes.

Literature Review

A literature search was conducted to acquire information from the existing body of knowledge on key performance indicators (KPI). The literature review began in the Learning Resource Center at the National Fire Academy in April, 2010 to locate Executive Fire Officer (EFO) research papers, publications and other resources related to KPIs in emergency medical services (EMS). Key terms used in the search were emergency medical services, performance indicators, clinical success indicators, quality assurance, performance improvement, paramedics and patient outcome. The search was expanded to the Internet in May, June and July, 2010.

Books, journal articles and one EFO paper were located to answer the first research questions on what measurable performance indicators were used to evaluate the effectiveness of an EMS system.

KPIs, also referred to as key success indicators (KSI), are a measurement of organizational success. Wikipedia (Anonymous) defines a KPI as a measurement of performance

used to help organizations define and evaluate how successful they were in making progress toward long-term goals and objectives. The operational mission and goals of LFR were to provide the citizens with emergency response services that minimized the loss of life and property from fires, medical emergencies and hazardous conditions.

KPIs are used to value difficult to measure activities such as customer satisfaction or service. A KPI should be understood and accepted by all stakeholders, meaningful and measurable. Historically few KPIs have been developed in EMS due largely in part to limited quality and quantity of data and a lack of pre-hospital research. EMS systems have used response time intervals and cardiac arrest survival rates as KPIs.

Swor & Pirrallo (2005) stressed the importance of developing KPIs for EMS in their book *Improving Quality in EMS.* KPIs allow government officials to use objective system data to establish policy, select EMS system design and monitor system performance for quality and effectiveness. The public and other stakeholders expect EMS managers to be accountable for system performance. KPIs help managers provide continuous quality system improvement, identify areas of excellence, highlight sentinel events, monitor corrective action and compare performance to established standards.

Swor &Pirrallo used three fundamental terms (performance indicators, performance measurements and benchmarking) when evaluating EMS system performance. *Performance indicators* are used to answer the question "How are we doing?" in making progress toward achieving the mission and goals of the EMS system. *Performance measurements* are used to quantify EMS system accomplishments through *benchmarking*. Benchmarking is a baseline used to evaluate performance of a program or service according to the indicators that have been established.

In 2007 the National Highway Traffic Safety Administration (NHTSA) in partnership with the National Association of State EMS Officials and the National Association of EMS Physicians completed a five year KPI project call the *EMS Performance Measures Project*. The goal of the project was to develop performance measurements to help local EMS systems measure, evaluate and benchmark system performance. Another objective was to establish common measurements nationwide. NHTSA advocated establishing a baseline or "benchmark" set of performance measurements that should be analyzed over a timeline to monitor and improve system performance. NHTSA emphasized that performance measurements should be assessed on a regular basis to improve overall system performance focusing on continual improvement to deliver quality service to the public (NHTSA, 2009).

The project's steering committee originally recommended over 100 performance indicators but narrowed the list to 25. NHTSA recommended measuring KPIs regularly and the rise or fall of these indicators would reveal performance trends. The 25 EMS system performance indicators and attributes recommended by NHTSA were:

1. Which Emergency Medical Dispatch Protocol Reference System (EMDPRS) does the EMS dispatch center use? *APCO, Medical Priority Dispatch System, Power Phone, Other, None*

2. Does your agency base its 'lights-and-sirens use response mode on the EMDPRS it uses?

3. Does your agency base its response level (ALS/BLS) dispatch on the EMDPRS it uses?
4. What is the turnover rate for EMS providers?
5. In cardiac arrest occurring prior to EMS arrival where defibrillation is attempted, what is the mean time and 90th percentile time from the public safety answering point (PSAP) contact to the initial defibrillation?

6. In cardiac arrest occurring prior to EMS arrival where an EKG is obtained, what are the mean time and the 90th percentile time from PSAP contact to initial analysis of rhythm?
7. What percentages of patients meet the 2006 CDC/ACS field triage criteria for transfer to a trauma center are transported to a trauma center?
8. Comparing first and last pain scale values, what percentage of patients older than 13 years of age reported decreased pain, increased pain or no change in pain?
9. What percentage of patients older than 13 reporting a pain value of seven or greater on a 0-10 scale received subsequent interventions associated with pain relief?
10. What percentage of patients over the age of 35 with suspected cardiac chest pain received a 12-lead EKG?
11. What percentage of patients over the age of 35 with suspected cardiac chest pain received aspirin?
12. What percentages of patients with a field 12-lead EKG indicating ST-elevation myocardial infarction (STEMI) were transported to hospital with emergency interventional cardiac catheterization capabilities?
13. What are the mean and 90^{th} percentile emergency patient response time intervals?
14. What are the mean and 90^{th} percentile emergency scene time intervals?
15. What are the mean and 90^{th} percentile emergency transport time intervals?
16. What is the total EMS cost per capita?
17. What percentages of patients were satisfied with their EMS experience?
18. What percentage of patients does your agency/system survey to measure patient satisfaction?

19. What percentage of patients in respiratory arrest/distress received oxygen?
20. What is the rate of undetected esophageal intubation?
21. What is the rate of EMS crashes per 1,000 responses?
22. What is the rate of EMS crashes per 100,000 fleet miles?
23. What is the rate of injuries and deaths because of EMS crashes per 100,000 fleet miles?
24. What are the number and distribution of primary complaints to which EMS responds?
25. What percentage of patients experiencing cardiac arrest after EMS arrival survives to discharge from the emergency department and discharge from the hospital?

In 2007 the U.S. Metropolitan Municipalities EMS Medical Directors Consortium developed evidence based performance measures to serve as a model to improve EMS system performance and enhance system benchmarking. Meyers et al. (2008) proposed evidenced-based KPIs that had a quantifiable impact on clinical outcomes for patients in large urban and suburban EMS systems.

Meyers et al. recommended an evidence based model of measuring system performance centered on six KPI areas that have proven scientific evidence to support improved patient outcomes. The six clinical performance areas were management of ST-elevation myocardial infarction (STEMI), treatment of pulmonary edema, asthma, seizure, trauma and cardiac arrest.

Each of the six clinical treatment areas had a defined *treatment bundle* or patient management strategy. Benefits from each element of the treatment bundle were only realized when all elements of the management strategy were completed together. The six key treatment areas with KPIs defined by Meyers et al. were:

1. ST-Elevation Myocardial Infarction (STEMI)
    a. Aspirin administration, if not allergic
    b. 12-Lead EKG with pre-arrival activation of an interventional cardiology team
    c. Direct transport to a coronary intervention facility capable of reperfusion in < 90 minutes
2. Pulmonary edema
    a. Nitroglycerin administration in the absence of contraindications
    b. Noninvasive positive pressure ventilations over endotracheal intubation
3. Asthma
    a. Administration of a beta-agonist
4. Seizure
    a. Blood glucose measurement
    b. Benzodiazepine given for status seizures
5. Trauma
    a. Limit non-entrapment scene time to < 10 minutes
    b. Direct transport to a trauma center for those meeting criteria, particularly those over 65

6. Cardiac arrest

    a. Response interval < 5 minutes for basic CPR and automated external defibrillators

Colwell et al. (2006) developed KPIs for patients with non-traumatic chest pain to determine if paramedics in Denver, Colorado were delivering quality comprehensive care. A treatment bundle scoring system was developed to grade the completeness of chest pain treatment. The treatment bundle's KPIs were oxygen, aspirin administration, lung sound assessment, vital signs, intravenous line establishment, EKG readings and cardiac risk factor assessment. The bundle score was considered unmet if any single element of the treatment bundle was not recorded. Colwell et al. discovered that while compliance with individual elements of the treatment bundle was generally good the comprehensive composite score was poor (39%). Colwell et al. concluded that;

> Quality-of-care measures, similar to those used for evaluating in-hospital care, can successfully be created and applied to pre-hospital emergency care. Pre-hospital care of patients with non-traumatic chest pain is not uniform and there is an opportunity for quality improvement measures targeted at improving the comprehensive care rendered to these patients (Colwell et al., 2006).

In summary, after an examination of the literature, it was discovered that there were clinical and operational KPIs developed to benchmark and improve EMS system performance. KPIs that improved patient outcomes and reduce mortality were the focus of this research.

The second research question examined how performance indicators improved patient care and outcomes? A search of the literature found research studies that had scientific evidence supporting improved patient outcomes.

For years response time data had been used as a KPI to benchmark performance of fire and EMS agencies national wide. After extensive research it was discovered that there were no federal or state laws that mandate a specific response time for fire suppression or medical care.

The National Fire Protection Agency (NFPA) recommended a response time interval for EMS incidents in NFPA Standard 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments.* NFPA 1710 defined response time as the travel time that begins when units were en route to the emergency incident and ends when units arrived at the scene. NFPA recommended a four minute or less response time for responders with a defibrillator and eight minutes or less for advanced life support (ALS) responders. An additional one minute call processing time was not included in their response time recommendations. NFPA suggested these response time objectives be met 90% of the time (NFPA, 2010).

Pons et al. (2005) studied the four minute and eight minute response time interval on patient outcomes in Denver, Colorado. The objective of the study was to evaluate the effectiveness of the four and eight minute response time interval on survival to hospital discharge in unselected patients. Pons et al. concluded, after retrospectively reviewing 9,559 patient transport records, that a "paramedic response time within eight minutes was not associated with improved survival to hospital discharge after controlling several important confounders, including level of illness. However, a survival benefit was identified when the response time was less than or equal to four minutes with intermediate or high risk mortality (Pons et al., 2005)."

Pons et al. concluded that the eight minute response time guideline did not improve patient outcomes and was not supported by the study results. They stressed the importance of identifying patients who may benefit from shorter response times, besides those in cardiac arrest.

This was ultimately required to provide both effective and safe out-of-hospital care. The study also suggested a better measurement of EMS system performance was from the customer's perspective. They recommended measuring response time from notification of the PSAP to treatment intervention. This time measurement, from onset of the symptoms to intervention, was more important to the customer and was a better benchmark of overall system performance.

A notable and significant response time interval that directly improved patient outcome was a rapid response to patients in cardiac arrest. Survival depends on a speedy response by paramedics to change the patient's heart rhythm from ventricular fibrillation or pulse-less ventricular tachycardia. Both are fatal heart rhythms. The American Heart Association (AHA) emphasized that early defibrillation and early ALS care by paramedics will improve patient survival. The AHA noted that brain death, or permanent irreversible death, begins within 4-6 minutes after cardiac arrest. Cardiac arrest can be reversed by a timely electrical shock from a defibrillator and early ALS interventions by a paramedic. AHA recommended starting CPR immediately with defibrillation administered within three to five minutes after collapse to reduce mortality from sudden cardiac arrest (AHA, 2010).

KPIs were discovered that improved patient outcome for patients with ST-elevation myocardial infarction (STEMI). Dieker and Jocobs (2010) studied the effect on patient outcome when paramedics transported STEMI patients directly to a cardiac interventional hospital after paramedic diagnosis of STEMI. After studying 581 patients with suspected STEMI indicators, Dieker and Jacobs determined patients transported to a interventional hospital had a higher likelihood of being treated within the 90-minute STEMI treatment guideline window. These patients had shorter symptom-to-balloon time for reperfusion and had a lower 1-year mortality rate (7% vs. 13%). "Our data underscores that efforts should be made to organize a large-scale

implementation of an infrastructure of pre-hospital diagnosis and direct transport to the intervention center with early notification of the catheterization laboratory from the ambulance (Dieker and Jacobs, 2010)."

De Luca, Suryaparanta, Ottervanger and Antman (2004) found similar conclusion when they studied the relationship between when the patient has symptoms to time of treatment on mortality in patients with STEMI. After following 1,791 STEMI patients for one year they concluded that "results suggest that every minute of delay in primary angioplasty for STEMI affects 1-year mortality even after adjustment for baseline characteristics. Therefore, all efforts should be made to shorten the total ischemic time, not only for thrombolytic therapy but also for primary angioplasty (De Luca, Suryaparanta, Ottervanger and Antman, 2004)."

KPIs were discovered that measured effectiveness of treatment for patients with respiratory distress, a frequent emergency run for LFR. Benchmarking administration of a beta agonist which can immediately reduce respiratory distress was a KPI recommended by Meyers et al. (2008). Albuterol was the beta agonist dispensed by LFR. Richmond, Silverman, Kusick, Mataliana and Winokur (2005) studied the administration of Albuterol by emergency medical technicians (EMT) in New York City. Their study concluded that EMTs could effectively administer Albuterol which had a direct effect on the outcome of patients in respiratory distress. Improvements in the patient's condition were noted after administration of Albuterol by EMTs. Clinical improvements after Albuterol treatment included the patient's ability to breathe easier and speak in full sentences, decreased respiratory distress and decreased pulse rate.

Another KPI measurement was the termination of seizures by administration of a benzodiazepine drug. Seizures were a recurrent call for LFR. The two benzodiazepines dispensed by LFR were Valium and Versed. These drugs were fast acting and effective in stopping

seizures. Alldredge et al. (2001) studied the effectiveness of paramedics giving a benzodiazepine to terminate seizures. They concluded that there was “clear evidence that intravenous benzodiazepines are safe and effective when administered by paramedics for the treatment of out of the hospital status epilepticus (Alldredge et al., 2001).” They recommended the drug Lorazepam over Valium even though both were effective in stopping seizures.

The goal of the third research question was to discover what methods were used by other EMS systems to evaluate EMS system performance and improve patient outcomes.

Lampretch (2007) used KPIs to measure the effectiveness of the EMS system at the Hobart Fire Department (HFD). HFD served a population of 26,000 people in 35 square miles in Northwest Indiana. The purpose of his research was to develop strategies to evaluate EMS system performance and improve patient outcome. Lampretch concluded that “cardiac arrest survivability rates were considered the gold standard for determining EMS effectiveness (Lampretch, 2007).” He recommended utilizing incident data to measure advanced life support skills performance. He also recommended measuring and benchmarking emergency response times and scene times since some medical conditions are time dependant for successful outcomes.

Coastal Valleys EMS Agency (CVEMSA) was a large multi-county regional EMS entity representing Sonoma, Napa and Mendocino Counties in California. CVEMSA provided medical oversight for 24 fire departments, eight ambulances agencies and three hospitals. CVEMSA used a three phase approach to monitor performance and improve the quality of care using KPIs. Their quality management approach included quality assurance, key performance measurements and process improvement.

CVEMSA collected incident data four times a year using a defined data set. They recognized that the data collected represented the quantity of activity but didn't reflect the quality of the medical care provided. Their goal was to enhance their EMS system's performance by adopting KPIs recommended by NHTSA and the EMS Performance Measures Project. KPIs were developed and adopted for cardiac, respiratory distress and trauma patients. CVEMSA followed a model for system improvement and stress that:

> This process of improvement relies on your local experts methodically testing changes, studying results, modifying changes as appropriate based on data, and identifying process improvements. It is a simple and effective method for teams to make substantive changes that improve and enhance care (CVEMSA, 2009).

The London Ambulance Service (LAS) used a number of clinical performance indicators (CPI) to benchmark performance and bring continual quality improvement to their service. LAS served a population of 7.6 million people in 625 square miles in London, England. Their CPIs were focused in areas with strong research evidence to prove that elements of the correct treatment bundle, when administered as a group, could directly improve patient outcomes.

CPIs were developed for the treatment of ST-elevation myocardial infarction (STEMI), cardiac arrest, stoke, hypoglycemia and respiratory distress. LAS audited 100% of these patient care reports and the data from CPIs were analyzed and benchmarked to improve performance. "The delivery of care in these areas is routinely audited by clinical leads, and the results of these audits are fed back to crew members on a one-on-one basis so they can make personalized recommendations on how they can improve performance. This process has led to clear improvements in care over time ("Quality Account," 2010)."

LAS used CPIs to increase cardiac arrest survival rates across their jurisdiction. With more than 10,000 out-of hospital cardiac arrests per year, LAS improved cardiac arrest survival rates from 6% in 2003 to 15.2% in 2009. Measuring CPIs improved the accuracy of documentation, increased protocol compliance and reduced scene times.

Procedures

Research procedures were developed to answer the three research questions on key performance indicators (KPI) in emergency medical services (EMS). Those procedures included a retrospective analysis of incident data, personal interviews and a national survey on KPIs.

The first research procedure was a retrospective analysis of Littleton Fire Rescue's (LFR) incident data to measure LFR's performance against KPIs discovered in the literature search. Clinical areas that were examined are in Appendix A. Data for the time period January 1, 2010 to June 30, 2010 was extracted from LFR's electronic records management system for analysis.

The second research procedure was personal interviews with two EMS medical directors. The purpose of the interviews was to learn how KPIs could impact care and affect patient outcomes. Interview questions are in Appendix B.

The third research procedure was a national survey on KPIs used by other EMS systems. Survey questions are in Appendix C. The purpose of the survey was to determine how other EMS systems measured performance. The survey was distributed using Survey Monkey, an Internet company specializing in survey development and distribution. A sample size of 100 respondents from different EMS systems was the goal. The survey distribution list was exclusive to students from the National Fire Academy who represented EMS systems around the country. The survey was distributed via email link in June, 2010. The survey requested information on the respondent demographics, KPIs related to: response time, cardiac arrest survival, ST-elevation

myocardial infarction, respiratory distress, seizures and trauma. The survey was open for data collection for 30 days. All results were collected anonymously through the Internet site.

There were a number of limitations in this study. The literature resources reviewed were assumed to be objective and unbiased. Data collection was performed retrospectively and limited to the reliability and accuracy of data input and correct documentation of each incident. The population of the data examined was limited to only patients transported by LFR. The non-specific trauma data analyzed was not categorized by severity level. The lack of a national repository for EMS data to establish common measurements and KPIs national wide was a limitation. The National EMS Information System (NEMSIS) project has started collecting EMS data but results were not available for this study.

Results

The first research procedure produced results from examining 3,861 medical incident reports. Results are in Appendix D. Data from Littleton Fire Rescue's (LFR) electronic records management system was used to analyze LFR's performance in treatment areas with key performance indicators (KPI) that had supporting scientific evidence to demonstrate improved patient outcomes.

Data from 2,228 patient transport records produced KPI results associated with response times, scene times and transport times. The average response time (notification of PSAP to arrival on scene) was 6:12 minutes and 6:00 minutes in trauma cases. LFR responded in 8:39 minutes and 9:00 minutes in trauma 90% of the time. The average scene time (arrival on scene to departure to hospital) was 18:59 minutes and 19:00 minutes in trauma. The average transport time (from scene to hospital) was 6:12 minutes and 12:00 minutes in trauma. All LFR's trauma patients (100%) were transported directly to a designated trauma center.

Data from 445 patient transport records produce KPI results associated with cardiac arrest, ST-elevation myocardial infarction (STEMI) and chest pain patients. Over half the cardiac arrest patients LFR responded to were not viable (50.7%) and were not transported to hospitals. Average time from PSAP notification to first defibrillation in patients with a shock-able cardiac rhythm was 12 minutes. Average time from first patient contact until first defibrillation was 3 minutes. Nearly a fourth of the cardiac arrest patients (22%) transported by LFR had a return of spontaneous circulation (ROSC) before they arrived at a hospital. LFR's cardiac arrest survival rate (discharge from hospital neurologically intact) was 11.4%.

Data from STEMI patients discovered that LFR paramedics had a high degree of accuracy (90%) in identifying STEMI and notifying the receiving hospital with a cardiac alert. Almost all STEMI patients (94%) received two 12-lead EKGs for clinical comparison. Data showed, on average, the first 12-lead EKG was recorded within five minutes from first patient contract. Most STEMI patients (89%) received aspirin. Average time from PSAP contact to heart reperfusion (E2B) was 101 minutes. Average time from first patient contact to reperfusion (R2R) was 88 minutes. Average time from arrival at the hospital to reperfusion (D2B) was 42 minutes. All STEMI patients (100%) were delivered to an interventional coronary facility.

Data from chest pain patients discovered treatment areas needing improvement. Not all chest pain patients received a 12-lead EKG (83.70%) or aspirin (60%) as required by medical protocol. Just half the chest pain patients transported (49.8%) received nitroglycerin for their chest pain and most (83.3%) had a notable reduction in their pain level after treatment.

Data from 308 patient transport records produced KPI results associated with managing respiratory distress. Results discovered the majority of patients (84%) received oxygen therapy. When a beta agonist was necessary due to the patient's condition LFR administered the drug, on

average, within 12 minutes from first patient contact. Only 43% of the patients treated with a beta agonist showed improvement. Some of the unstable respiratory distress patients (12%) were treated with constant positive air pressure (CPAP) therapy. On average CPAP treatment was started within 11 minutes from first patient contact and most patients treated with CPAP (88%) showed improvement after treatment. There were no undetected esophageal intubations (n=0) reported from 62 out-of-hospital intubations performed by LFR paramedics.

Data from 148 patient transport records produced KPI results associated with treating seizures. A small percentage of patients (13%) who experienced seizures did not require transport to a hospital. Most seizures patients (89%) had their blood glucose level checked, on average, within 7 minutes of first patient contact. Only a small percentage of patients (7%) required treatment with a benzodiazepine drug to stop their seizures. On average the drug was administered within 14 minutes from arrival at the patient's side. The benzodiazepine was effective in stopping seizures 60% of the time after administration.

Data from 276 patient transport records produced KPI results associated with treating patients in pain from various medical or trauma conditions. Not all patients treated for pain (79%) had their pain level checked before and after treatment as recommended. Most patients treated with a narcotic for pain (80%) reported a decreased in their pain level after treatment. A large percentage of patients with a pain scale above seven (71%) had subsequent narcotic treatments to reduce their pain after the initial therapy proved less than effective.

The second research procedure produced results from interview questions presented to EMS medical directors from the two primary hospitals that LFR transported their patients to.

A personal interview was conducted on September 19, 2010 with Dr. Gene Eby, EMS Medical Director for Littleton Fire Rescue. Dr Eby had been the EMS Medical Director for 15

years at Littleton Hospital, a level 2 trauma center located in Littleton, Colorado. LFR transported most of their patients (66%) to Littleton Hospital in 2009 (“Annual Report,” 2009). The purpose of the interview was to determine how KPIs improved patient outcomes at Littleton Hospital.

Dr. Eby used KPIs to develop a very successful *cardiac alert* program now used by other hospitals nationwide. The program improved treatment and outcomes for ST-elevation myocardial infarction (STEMI) patients by measuring KPIs. “By benchmarking three KPIs (12-lead EKG, aspirin administration and transport time) we improved compliance with medical treatment protocols, reduced transport times and improved overall survival for STEMI patients by reducing door-to-balloon (D2B) reperfusion time at the Littleton Hospital (Eby, personal communication, September 19, 2010).”

Dr. Eby used aspirin administration (ASA), an important medication given by paramedics when treating heart attacks, as a performance indicator. The cardiac alert program was initially developed by measuring and benchmarking ASA administration. “We first started out measuring one isolated KPI, ASA administration, for protocol compliance. We discovered our compliance for ASA administration in STEMI treatment was just 50%. We improved ASA administration compliance to 90 % through repeated benchmarking and education of our paramedics" Eby stated. Benchmarking KPIs significantly improved the overall EMS system performance, improved individual paramedic performance and changed patient outcomes. “Door to balloon treatment times (D2B) were reduced from an average of 120 minutes, just a few years ago, to a low of 22 minutes for some patients today” Eby stated. “We know that treating heart attack patients is time dependent and time is heart muscle. Reducing D2B time equates to less cardiac damage, shorter rehabilitation time for the patient and less medical expense.”

Dr. Eby remarked that developing KPIs in other areas of EMS could vastly improve patient care. “Just do it. Develop measure and benchmark KPIs” commented Eby. “You never know what you might find in the data, where it may take you or how it will improve patient care. We never dreamed the cardiac alert program, now used nationwide, would have evolved from simply measuring ASA administration.”

A personal interview was conducted on September 16, 2010 with Dr. Dylan Luyten, EMS Medical Director at Swedish Hospital. Dr Luyten had been EMS Medical Director at Swedish Hospital, a level 1 trauma center located in Englewood, Colorado, for the past seven years. LFR had transported patients to Swedish Hospital for 35 years. The purpose of the interview was to determine how KPIs improved patient outcomes at Swedish Hospital.

Dr. Luyten remarked that the development of KPIs in EMS had progressed slowly due to the lack of good data management tools and little pre-hospital research. His observations were that patient outcomes were never tracked well in the past so the lack of KPIs could be expected. He believed that new data management systems and further pre-hospital research has led to better data analysis and more widespread use of KPIs. “I believe we have seen a dramatic improvement in patient care and outcome at Swedish Hospital because of increased benchmarking of clinical performance indicators, especially in the area of cardiac care” stated Luyten (Luyten, personal communication, September 16, 2010).

Dr. Luyten separated KPIs into two groups. The first group improved the EMS system but had little or no direct correlation to patient outcomes. The example used was patient satisfaction surveys. Dr. Luyten stressed the most important KPIs to measure were clinically significant to the patient’s outcome and supported by scientific research data. The example used was the cardiac alert program which was based on scientific evidence. Because of KPIs for

STEMI patients Swedish Hospital had dramatically reduced D2B times from 90-120 minutes to 50-75 minutes. Dr. Luyten equates this improvement to one life saved for every 15 STEMI patients transported by LFR. “Benchmarking KPIs in STEMI treatment has allowed Swedish Hospital to standardize the EMS response to STEMI patients which in turn has improved patient outcomes and reduce mortality.”

The third research procedure produced KPI results using a national survey. Respondents were asked to answer questions on which KPIs they used in their EMS system to improve patient care and outcomes. The survey results are in Appendix E.

Results were produced from 150 surveys sent to respondents across the country. The survey had an 81% survey return rate (n=122). Results were returned from 36 states. Most of the survey results (69.7%) came from fire based EMS systems and a small percentage (13.1%) came from fire departments without EMS. Other EMS system configurations accounted for fewer than 5% each.

Most respondents (91.7%) indicated that their EMS systems used response time data as a KPI. Over half (54.2%) indicated their systems were analyzing cardiac arrest survival data. Historically EMS systems have used these two KPIs as the hall mark measurements of system performance.

Respondents indicated their EMS systems were benchmarking key elements in STEMI treatment. Most measured aspirin administration (73%) which is an essential drug given in STEMI treatment. The majority of EMS systems (75%) benchmarked the time when a 12-lead EKG was taken and over half (52%) measured the time from PSAP notification to reperfusion (E2B).

The majority of EMS systems were benchmarking performance in cardiac arrest resuscitation. Most EMS systems (71%) measured the time from when the cardiac arrest occurred to when basic life support was started and the majority (77%) tracked the use of automated external defibrillators. Cardiac arrest survival rates (discharge from hospital neurologically intact) reported in the survey varied from 3-44% with an average of 22%.

Respondents were asked about KPIs in the treatment of respiratory distress. Over half of the respondents (58%) indicated their EMS systems measured administration of a beta agonist. Many (63%) benchmarked respiratory distress level before treatment most (70%) also measured respiratory distress level after treatment

Recommended KPI measurements to evaluate EMS performance in treating seizure patients were measurement of blood glucose level (BGL) and administering a benzodiazepine drug to terminate the seizure. Respondents to the survey indicated that most EMS systems (71%) were benchmarking BGL but only half (53%) were benchmarking how quickly the benzodiazepine was administered.

A recommended KPI to improve outcomes in trauma patients was keeping non-entrapment scene times below 10 minutes. The majority of respondents (79%) indicated that their respective EMS systems measured elapsed scene times in trauma cases. Most respondents (69%) indicated their EMS system also monitored which patients were transported to trauma centers and which were not.

Discussion

The purpose of this research project was to investigate and develop key performance indicators (KPI) to measure the effectiveness of medical care provided by Littleton Fire Rescue (LFR). Antidotal evidence indicated LFR was providing excellent care that improved patient

outcome and reduced mortality. The objective of this research was to prove or disprove that theory.

Sowr & Pirrallo (2005) emphasized that KPIs are essential measurements in system evaluation and can improve the overall quality and effectiveness of care. Results discovered KPIs in two areas of EMS; operational KPIs and clinical KPIs. Dr. Dylan Luyten, EMS Medical Director at Swedish Hospital, recommended EMS managers focus quality improvement efforts on clinical performance (Luyten, personal communication, September 16, 2010). These results narrowed the focus of this study to KPIs that improved patient outcomes.

Response time and scene time KPIs were directly associated with successful patient outcomes. The treatment of certain medical conditions was time dependant and delays in response time or transport time can be associated with increased mortality. Results from the national survey found the majority of respondents (91.7%) were benchmarking response time data as a KPI.

KPI results found LFR was meeting NFPA's recommended response time standard of eight minutes for advanced life support (NFPA, 2010). 90% of the time LFR paramedics were on scene within eight minutes (7:39) and on average they arrived within 5:12 minutes (subtracting one minute call processing time). Meyers et al. (2008) advocated measuring two KPIs in the treatment of trauma patients, one of which was time dependant. Patient outcomes were associated with limiting non-entrapment scene time to less than 10 minutes and transporting trauma patients directly to a designated trauma center. Results showed that LFR's scene times were long (19 minute) in non-specific trauma. LFR's scene times should be reduced. LFR transported all trauma patients (100%) directly to a designated trauma center as recommended by Meyers et al.

The design of LFR's EMS system was advantageous for a rapid ALS response. A paramedic was staffed on every firefighting unit and ALS interventional care was started immediately on arrival of the closest unit. In a study of the eight minute response time, Pons et al. (2005) stressed that EMS agencies should identify which medical conditions were dependant on a rapid response and strike a balance between providing effective medical care and the safety of the public and the responders.

Both Meyers et al. (2008) and NHTSA (2009) proposed benchmarking KPIs in the treatment of chest pain, STEMI and cardiac arrest. Results from the national survey found the majority of respondents (73%) were benchmarking elements of the STEMI treatment bundle. Most (73%) were monitoring aspirin (ASA) administration and 12-lead EKG times (75%) while only half of those who responded to the survey (52%) benchmarked reperfusion time. Half the respondents (54%) tracked cardiac arrest survival rates as a KPI. Cardiac arrest survival rates, as reported in the national survey, ranged from 3-44% with the average hospital discharge rate of 22%.

KPI results determine that LFR could improve treatment for chest pain patients by closely benchmarking elements of the treatment bundle. While most patients received a 12-lead EKG (83.7%) not all did. Acquiring a diagnostic 12-lead EKG is the standard of care in treating chest pain patients. All patients 35 years of age and older with chest pain should have received ASA but only a portion of those patient did (60%). Chest pain management could also be improved with only half of chest pain patients (49.8%) receiving nitroglycerin to reduce their pain level. Improvement in these KPIs was recommended. Colwell et al. discovered that pre-hospital care was often not uniform and by measuring and benchmarking KPIs there is an opportunity to enhance comprehensive care and improve patient outcomes (Colwell et al., 2006).

KPI results confirmed that LFR's performance in STEMI treatment was directly influencing patient outcomes in a positive manner. LFR correctly indentified STEMI patients 90% of the time and activated a cardiac alert at the receiving hospital. Nearly all of the STEMI patients (94%) received two 12-lead EKGs for clinical comparison with the first EKG being performed, on average, within five minutes from first patient contact. Nearly all STEMI patients (89%) received ASA. Dieker and Jacobs (2010) stress the importance of transporting STEMI patients to an interventional coronary facility and found these patients had a lower one year mortality rate. LFR transported all of its STEMI patients (100%) to an interventional coronary facility.

Results showed that LFR's average time from first patient contact until reperfusion (R2R) was 88 minutes. Meyers et al. (2008) emphasized the importance of keeping R2R time to less than 90 minutes for successful STEMI outcomes. The average time from LFR's arrival at the hospital until reperfusion (D2B) was 42 minutes. Dieker and Jacobs (2010) determined patients transported to a cardiac interventional hospital had a higher likelihood of being treated within the 90-minute STEMI treatment guideline window. These patients had shorter symptom-to-balloon time for reperfusion and had a lower 1-year mortality rate (7% vs. 13%). Dr. Gene Eby, LFR's Medical Director, stressed the importance of reducing D2B time to improve patient outcomes. Rapid reperfusion equates to less cardiac damage, shorter rehabilitation time and less medical expense (Eby, personal communication, September 19, 2010).

KPI results confirmed that LFR was performing well in the treatment of cardiac arrest patients. 22% of patients transported by LFR in cardiac arrest had return of spontaneous circulation before they arrived at the hospital and 11.4% survived to hospital discharge neurologically intact. By comparison, London Ambulance Service, with 10,000 cardiac arrests

per year, had a 6% cardiac arrest survival rate which increased to 15.2% after KPI benchmarking ("Quality Account," 2010). LFR paramedics treated cardiac arrest patients quickly after first patient contact by defibrillating shock-able heart rhythms, on average, within three minutes. The American Heart Association (AHA) emphasized that early defibrillation and early ALS care by paramedics will improve patient survival. Cardiac arrest can be reversed by a timely electrical shock from a defibrillator. AHA recommended starting CPR immediately with defibrillation within three to five minutes after collapse to reduce mortality from sudden cardiac arrest (AHA, 2010).

NHTSA (2009) recommended benchmarking two KPIs in patients with respiratory distress; oxygen administration and rate of undetected esophageal intubation. Meyers et al. (2008) also advised measuring beta agonist administration as a KPI in respiratory distress. Over half of the respondents answering the national survey (58%) were benchmarking administration of a beta agonist.

KPI results established LFR was performing favorably in the treatment of respiratory distress. The majority of patients in respiratory distress received oxygen (84%) and when a beta agonist was required (12% of the cases), on average, it was administered within 12 minutes from first patient contact. Richmond, Silverman, Kusick, Mataliana and Winokur (2005) found administration of a beta agonist by EMTs directly reduced respiratory distress and improved patient outcome. Only 43% of LFR's patients treated with a beta agonist improved after treatment. Patients that remained in distress after pharmacological treatment failed to improve their condition were treated with a constant positive airway pressure (CPAP) mask. Most patients treated with CPAP (88%) showed immediate improvement and did not required tracheal

intubation. In the 62 patients who required intubation from respiratory or cardiac arrest no undetected esophageal intubations (n=0) were reported.

Meyers et al. (2008) recommended measuring two KPIs in the treatment of seizure patients that directly affected their outcome by immediately terminating the seizure. KPIs in the treatment bundle were benchmarking blood glucose measurements and administration of a benzodiazepine drug to terminate the seizure. Results from the national survey showed that most EMS agencies (71%) monitored blood glucose measurements but only half (53%) were benchmarking benzodiazepine administration. Alldredge et al. (2001) studied the effectiveness of benzodiazepine administration by paramedics and concluded there was "clear evidence that intravenous benzodiazepines are safe and effective when administered by paramedics for the treatment of out of the hospital status epilepticus (Alldredge et al., 2001)."

KPI results showed that LFR was adequately treating seizure patients by quickly analyzing blood glucose levels and, in a small amount of cases (7%), administering a benzodiazepine drug. Most seizure patient (89%) had their blood glucose level checked, on average, within seven minutes from first patient contact. While only a small number of patients (n=11) needed benzodiazepine treatment, on average, the drug was administered within 14 minutes of first patient contact. LFR's treatment stopped the seizures in 60% of the patients.

NHTSA (2009) recommended measuring two KPIs in the treatment of patients with pain; evaluation of the patient's first and last pain level to assess treatment effectiveness and the percentage of patients, older than 13 years of age with a pain scale above seven, who received subsequent pain management interventions.

KPI results recognized that LFR could improve in the clinical treatment of patients with pain. It was discovered that most patients (79%), but not all, had their pain level checked before

and after treatment as NHTSA advocated. Patients older than 13 years of age, with a pain scale above seven, should have had subsequent pain treatment but only 71% of the patients were given further pain management treatments as recommended (NHTSA, 2009).

This researcher interpreted the KPI results in this study to support the theory that LFR was providing excellent emergency medical care that positively influenced patient outcomes and reduced mortality. While past antidotal evidence supported this theory now quantifiable research data proved that LFR's expert medical staff was providing quality medical care. Results also illustrate that there were elements of LFR's treatment requiring improvement and recommendations based on this research study were suggested.

The organizational implication of this research will change the standard of emergency medical care delivered by LFR paramedics and directly improve patient outcomes. A new comprehensive quality improvement strategy centered on developing, measuring and benchmarking KPIs has evolved from this research study and will be put into practice.

Recommendations

Recommendations to enhance patient care at Littleton Fire Rescue (LFR) and improve patient outcomes have resulted from this research study on key performance indicators (KPI). The following recommendations, supported by KPI data collected and analyzed during this research, are divided into two areas; clinical and operational.

Clinical recommendations will improve patient care and outcomes. Based on this research the following clinical recommendations were made:

1. LFR should reduce non-entrapment scene times in trauma cases from 19 minutes to less than 10 minutes.

2. LFR should increase the percentage of chest pain patients who receive a 12-lead EKG from 83% to 100%. Increase the percentage of chest pain patients, 35 years and older, receiving aspirin from 60% to 100%. Increase the percentage of patients receiving nitroglycerin to reduce their chest pain from 49.8% to 100%.
3. LFR should benchmark the rescue to reperfusion time (R2R) in STEMI treatment and maintain the 90 minute or less benchmark for cardiac reperfusion.
4. LFR should increase the hospital discharge rate from cardiac arrest from 11.4% to 25% by benchmarking KPIs.
5. LFR should increase the percentage of patients who receive oxygen in respiratory distress from 84% to 100%.
6. LFR should increase the percentage of patients that have their pain level checked before and after LFR treatment from 79% to 100%.
7. LFR should increase the percentage of patients, 13 years of age and older with a pain scale greater than seven, who received subsequent treatment with a narcotic for pain from 71% to 100%.

Operational recommendations will improve overall EMS system performance and enhance customer service. Based on this research the following operational recommendations were made:

1. LFR should develop, analyze and benchmark KPIs in non-clinical areas to enhance overall EMS system performance and improve customer service. KPIs and their subsequent data should be posted on the fire department's web site for transparency and accountability.

2. LFR should monitor individual paramedic performance using KPIs and give feed back to crew members on a one-to-one basis to personalize recommendations to improve individual paramedic performance.
3. LFR should develop and benchmark KPIs in the following operational areas; communication center, light-and-sirens response, EMS cost per capita, patient satisfaction, primary EMS complaints and EMS accident and injuries.
4. LFR should educate all LFR staff members on the results of this study and benchmark established and accepted KPIs every six months.
5. LFR should use EMS training classes to simulate tracheal intubations since only 62 intubations were performed in a six months.
6. LFR should use data benchmarking to improve EMS documentation.
7. LFR should collect and analyze data on patient satisfaction. Patient satisfaction surveys should be included with patient transport bills and results posted on the fire department's web site.

Recommendations from this research study will improve the standard of care at LFR by benchmarking KPIs every six months. Organizationally, LFR should expand the use of KPIs into all aspects of the fire department. This data driven continuous quality improvement process will provide decision makers, customers and payers with objective data and quantifiable evidence that they are receiving value and quality for the cost of the services they are paying for.

In conclusion, future readers and researchers may wish to perform a similar assessment of their fire department's performance using KPIs. This researcher hopes the information contained in this research study will be a model for others to use to support improvement efforts and demonstrate accountability for the services we provide the public. Finally, this researcher

encourages other fire and EMS professional to aggressively pursue research and become well educated in the quality improvement process.

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Appendix A

Littleton Fire Rescue KPI Data Analysis Areas

1. Response times
2. Cardiac arrest survival rates
3. ST-evaluation myocardial infarction
4. Chest pain treatment
5. Respiratory distress treatment
6. Constant positive airway pressure (CPAP) treatment
7. Seizure treatment
8. Trauma
9. Pain management

Appendix B

Medical Director Interview Questions

1. What is your name and title?

2. What is your background as a medical director?

3. Can you describe how the development of key performance indicators improves patient care?

4. Can you give examples of how measuring and benchmarking key performance indicators have improved patient outcomes at your hospital?

Appendix C

National Key Performance Indicator Survey Questions

1. What type of EMS agency are you affiliated with?

2. What state is your agency in?

3. Does your agency analyze response time data to monitor and improve system performance?

4. Does your agency analyze performance indicators for ST-myocardial infarction (STEMI)?

5. Does your agency analyze cardiac arrest survival rates?

6. Does your agency analyze performance indicators for patients with respiratory distress?

7. Does your agency analyze performance indicators for seizure patients?

8. Does your agency analyze performance indicators for trauma patients?

9. Does your agency analyze performance indicators for chest pain patients?

10. Does your agency analyze performance indicators for patients in pain?

11. Does your agency examine patient satisfaction data?

12. Does your agency analyze performance indicators related to EMS operations?

13. What other key performance indicators does your agency analyze to improve system performance?

Appendix D

Result Littleton Fire Rescue KPI – Data Analysis

Table D1

Response Time Data Summary	**Results**
Total number of records reviewed	2285
Exclusions	57
Number of records studied (n)	2228
Mean emergency response time interval (call to PSAP until arrival at patients side)	6:12 minutes
90th % emergency response time interval (call to PSAP until arrival at patients side)	8:39 minutes
Mean emergency scene time interval	18:59 minutes
90th % emergency scene time interval	26.55 minutes
Mean emergency transport time interval	6:12 minutes
90th % emergency transport time interval	20:30 minutes

Table D2

Response Time Data Summary - Trauma	**Results**
Total number of records reviewed	479
Exclusions	23
Number of records studied (n)	456
Mean age of patients suffering trauma	49
% of trauma patients transported to a trauma center	100%
Mean response time interval for patients suffering trauma	6:00 minutes
90th % response time interval for patients suffering trauma	9:00 minutes
Mean emergency scene time interval for patients suffering trauma	19 minutes
90th % emergency scene time interval for patients suffering trauma	29 minutes
Mean transport time interval for patients suffering trauma	12 minutes
90th % transport time interval for patients suffering trauma	20 minutes

Table D3

Cardiac Arrest Data Summary	Results
Total number of records reviewed	71
Exclusions	1
Number of records studied (n)	70
Mean age of patients suffering cardiac arrest	59.5 years
% of cardiac arrest patients that were not transported (left on scene)	50.70%
% of patients transported with return of spontaneous circulation prior to reaching the hospital emergency department	22%
% of patients transported that survived discharged from the ED	22.80%
% of patients transported that survived discharged from the hospital	12.80%
% of patients transported that survived discharged from the hospital and neurologically intact	11.40%
% of patients transported that had bystander CPR and ROSC	10%
% of patients transported that had Autopulse and ROSC	8.50%
% of patients transported that had ROSC with bystander CPR and Autopulse	5.70%
Mean time - 1st patient contact to defibrillation in patients with a shock-able cardiac rhythms	3 minutes
Mean time - PSAP contact to defibrillation in patients with a shock-able cardiac rhythms	12 minutes

Table D4

STEMI Data Summary	Results
Total number of records reviewed	23
Exclusions	5
Number of records studied (n)	18
Mean age of STEMI patients	64.4 years
Mean time from activation of EMS until reperfusion (E2B)	101 minutes
90th % time from activation of EMS until reperfusion (E2B)	118 minutes
Mean time from 1st patient contact until reperfusion (R2R)	88 minutes
90th % time from 1st patient contact until reperfusion (R2R)	105 minutes
Mean time from hospital arrival until reperfusion (D2B)	42 minutes
Mean time from 1st patient contact until first 12-lead EKG	5 minutes
% of STEMI patients who received ASA	89%
% of cardiac alerts called by LFR that met the criteria	90%
% of patients that received two 12 lead-EKGs for comparison	94%
% of patients transported to a coronary intervention facility	100%

Table D5

Chest Pain Data Summary	Results
Total number of records reviewed	394
Exclusions	37
Number of records studied (n)	357
Mean age of chest pain patients	64 years
% of patients with cardiac chest pain who received a 12-lead EKG	83.70%
% of patients > 35 years old with cardiac chest pain receiving ASA	60%
% of patients with cardiac chest pain who received Nitroglycerin	49.80%
% of patients with reduction in their pain level from LFR treatment	83.30%

Table D6

Respiratory Distress Data Summary	Results
Total number of records reviewed	275
Exclusions	0
Number of records studied (n)	275
Mean age of patients with respiratory distress	58 years
% of patients with respiratory distress that received oxygen	84%
Mean time for1st patient contact until beta agonist given	12 minutes
% of patients treated for respiratory distress that show improvement after treatment	43%
Rate of undetected esophageal intubation	0

Table D7

CPAP Data Summary	Results
Total number of records reviewed	33
Exclusions	0
Number of records studied (n)	33
Mean age of patients receiving CPAP	69 years
% of patients with respiratory distress treated with CPAP	12%
% of patients improved after treatment with CPAP	88%
Mean time from 1st patient contact to oxygen administration	6 minutes
Mean time from 1st patient contact to CPAP application	11minutes

Table D8

Seizure Treatment Data Summary	**Results**
Total number of records reviewed	150
Exclusions	2
Number of records studied (n)	148
Mean age of patients treated for seizures	33 years
% of patients who had seizures but were not transported	13%
% of patients who had a blood glucose level checked	89%
Mean time from 1st patient contact until first blood glucose reading	7 minutes
% of patients with seizures who were treated with Benzo	7%
Mean time from 1st patient contact until Benzo given	14 minutes
% of patients treated with a Benzo that improved after treatment (seizures stopped)	60%

Table D9

Pain Treatment Data Summary	Results
Total number of records reviewed	276
Exclusions	0
Number of records studied (n)	276
Mean age of patients treated with narcotics for pain	54 years
% of patients that had their pain level taken before and after narcotics administration	79%
% of patients > 13 years of age that reported a decrease in pain	80%
% of patients > 13 years of age with a pain scale >7 that received subsequent treatment for pain	71%

Appendix E

Results - National KPI Survey Questions

Table E1

What type of EMS agency are you affiliated with?		
Answer Options	**Response Percent**	**Response Count**
Fire service only	13.1%	16
Fire and EMS service combined	69.7%	85
County EMS service	3.3%	4
City EMS service(separated from fire)	4.1%	5
Hospital EMS service	2.5%	3
Private EMS service	3.3%	4
Air ambulance EMS service	0.8%	1
Other	3.3%	4
Other (please specify)		7

Table E2

What State is your agency in?		
Answer Options	**Response Percent**	**Response Count**
State:	100.0%	122

Table E3

Does your agency analyze response time data to monitor and improve system performance?		
Answer Options	**Response Percent**	**Response Count**
Yes	91.7%	110
No	8.3%	10
I don't know	0.0%	0

Table E4

Does your agency analyze cardiac arrest survival rates (patient discharged from hospital) to improve system performance?		
Answer Options	**Response Percent**	**Response Count**
Yes	54.2%	65
No	41.7%	50
I don't know	4.2%	5
Cardiac Arrest Survival Rate (if known)		20

Table E5

Performance indicators for ST-Elevation Myocardial Infarction (STEMI) patients?				
Answer Options	**Yes**	**No**	**I don't know**	**Response Count**
Aspirin administration	71 (73%)	19 (20%)	7 (7%)	97
12-Lead EKG times	73 (75%)	19 (20%)	5 (5%)	97
Reperfusion in <90 minutes from time of call to EMS	49 (52%)	34 (35%)	12 (13%)	95

Table E6

Performance indicators for cardiac arrest patients?				
Answer Options	**Yes**	**No**	**I don't know**	**Response Count**
Response time interval < 5 minutes for basic CPR	68 (71%)	21 (22%)	7 (7%)	96
Bystander CPR	67 (71%)	22 (22%)	8 (7%)	97
Use of automated external defibrillators	75 (77%)	18 (19%)	4 (94%)	97

Table E7

Performance indicators for patients with respiratory distress?				
Answer Options	**Yes**	**No**	**I don't know**	**Response Count**
Administration of a beta-agonist	56 (58%)	29 (30%)	12 (12%)	97
Respiratory distress level before treatment	61 (63%)	28 (30%)	8 (8%)	97
Respiratory distress improvement after treatment	67 (70%)	23 (24%)	6 (6%)	96

Table E8

Performance indicators for patients with pulmonary edema?				
Answer Options	**Yes**	**No**	**I don't know**	**Response Count**
Nitroglycerin administration	58 (60%)	29 (30%)	10 (10%)	97
Use of Noninvasive Positive Pressure Ventilations (CPAP)	66 (69%)	22 (23%)	8 (8%)	96

Table E9

Performance indicators for patients with seizures?				
Answer Options	**Yes**	**No**	**I don't know**	**Response Count**
Blood glucose measurement	69 (71%)	22 (23%)	6 (6%)	97
Time of Benzodiazepine administration to stop seizures	51 (53%)	36 (37%)	10 (10%)	97

Table E10

Performance indicators for trauma patients?				
Answer Options	**Yes**	**No**	**I don't know**	**Response Count**
Elapsed scene time	77 (79%)	16 (17%)	4 (4%)	97
Number of patients transported to a trauma center	66 (69%)	25 (26%)	5 (5%)	96